Chapter 9: JSC Particle Telescope

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JSC Particle Telescope

PHIDE Instrument Description

Figure 1 is a schematic of the telescope geometry. It consists of two 1 mm thick lithium-drifted silicon detectors A1 and A2 that define the geometry of the telescope to be 35° opening angle. These two detectors are followed by four 5 mm thick lithium-drifted detectors (B1 to B4), a 1 mm thick lithium-drifted detector A3 and a sapphire Cerenkov detector, C, which is view by a photomultiplier tube. The whole telescope is surrounded by an NE 102 plastic scintillator mantle, D, that is view by 3/4" diameter photomultiplier tubes. The output of the two opposite tubes is summed and thus there are two independent measurements D1 and D2 from this anti-coincidence detector. Figure 2 is very simplified block diagram of the electronics. The basic trigger of this telescope is A1, A2 and require an incident proton energy > 13 MeV. If this trigger is satisfied, then each of the detectors Al, A2, B1, ... B4, A3, C, and D1 and D2 are pulse height analyzed into 4096 channel analog to digital converter (ADC). In addition, counting rates in each of these detectors is monitored every 10 s, as are the coincidence rates. The linearity and calibration of detector electronics is checked every 4 h using a precision pulse generator. The flight data is recorded on two 20 MB hard disks.

The detector telescope operates in three data modes. Only particles that do not trigger the anti-coincidence scintillator D are analyzed. If the particle stops in any of the detectors then the telescope acts as a double dE/dx x E detector system. For such particles, plot of energy loss ΔE versus total residual energy, E, are hyperbolas corresponding individual isotopes.

$$\Delta E \times E \;\alpha\; M^{n-1} Z^2$$

The mass M, charge Z, and energy per nucleon can be calculated using the range-energy relationship, R (E/M) = $(Z^c/M)\, K\, E^n$. The constant K and n are obtained by least square fit to the standard range-energy tables for silicon (sapphire). The area-solid angle product (AΩ) varies from 6.23 to 12 CM^2 sr, for an isotropic incident particle flux, depending upon where the particle stops in the detector stack.

If the particle passes through A3, triggers C (AΩ = 6.23 CM^2 sr) without stopping, and gives signal in excess of the scintillation signal, the telescope is the double dE/dx x C mode. In

this case particles with threshold (β_0) energy of > 200 MeV/n. With at least two measurements of ΔE from A1 and A2 (Z^2/β^2) and $C = K_2 Z^2 [1-(\beta_0/\beta)^2]$, one can calculate the charge Z and

velocity of energy/nucleon.

In the intermediate energy range where the particles did not stop in the detector stack or produce a Cerenkov signal, the particles are now known to have energy in the range of ~ 100 -200 MeV/n. In this case, one compares the measurements of energy loss in all seven solid-state detectors Al, A2........ A3, with calculated energy losses in silicon for particle with energy between 100 -200 MeV/n. The energy that gives the best fit to the seven measurements is the incident particle energy. This is done by minimizing the chi-square, χ^2,

$$\chi^2 = \sum[\Delta E_i^{\text{obs}} - \Delta E_i^{\text{meas}}]^2$$

Flight Experience

The system was designed to take data serially with minimal attendance, and the pressure-tight housing had to be opened in order to download the data for analysis. After the engineering flight, the housing was opened, data downloaded, the housing reassembled, and PHIDE placed back in the ER-2. Analysis of the data later showed that the detectors were not receiving power. A subsequent disassembly showed that the main connector had a bent pin that shorted the power and damaged the instrument. No useful data was collected during the first flight series. For the next flight series, provision will be made for downloading data without opening the housing.

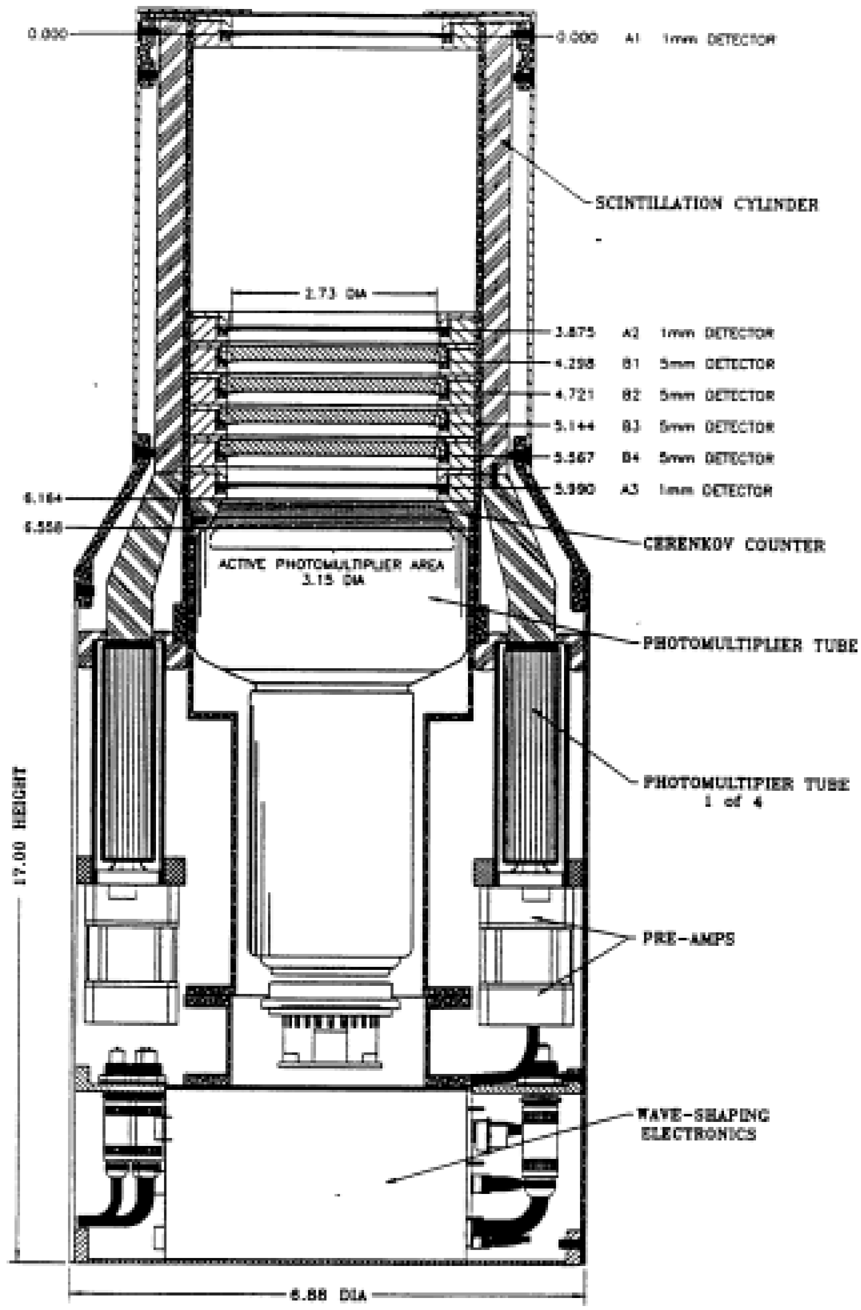

Fig. 1. A schematic diagram of the detector telescope.

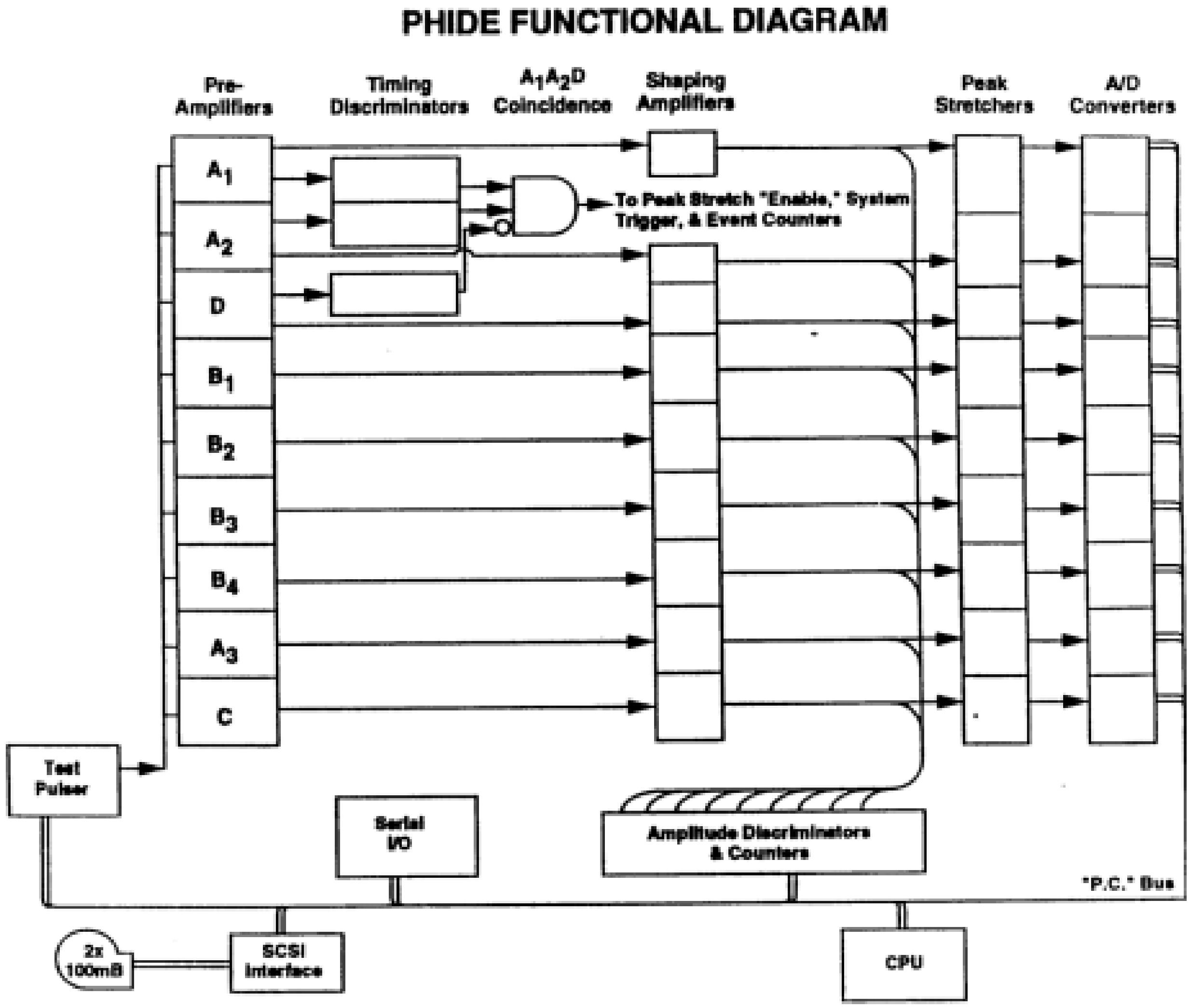

Fig. 2. An electronic block diagram of the detector telescope.